Function-Oriented Software
Design (continued)

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(source: Rajib Mall)

Example 3: Trading-House Automation
System (TAS)

A large trading house wants us to develop a software:

- To automate book keeping activities associated with its business.

It has many regular customers:

- Who place orders for various kinds of commodities.

Example 3: Trading-House Automation System (TAS)

The trading house maintains names and addresses of its regular customers.

Each customer is assigned a unique customer identification number (CIN).

As per current practice when a customer places order:

- The accounts department first checks the creditworthiness of the customer.

Example: Trading-House Automation System (TAS)

The credit worthiness of a customer is determined:

- By analyzing the history of his payments to the bills sent to him in the past.

If a customer is not credit-worthy:

- His orders are not processed any further
- An appropriate order rejection message is generated for the customer.

Example: Trading-House Automation System (TAS)

If a customer is credit-worthy:

- Items he/she has ordered are checked against the list of items the trading house deals with.

The items that the trading house does not deal with:

- Are not processed any further
- An appropriate message for the customer for these items is generated.

Example: Trading-House Automation System (TAS)

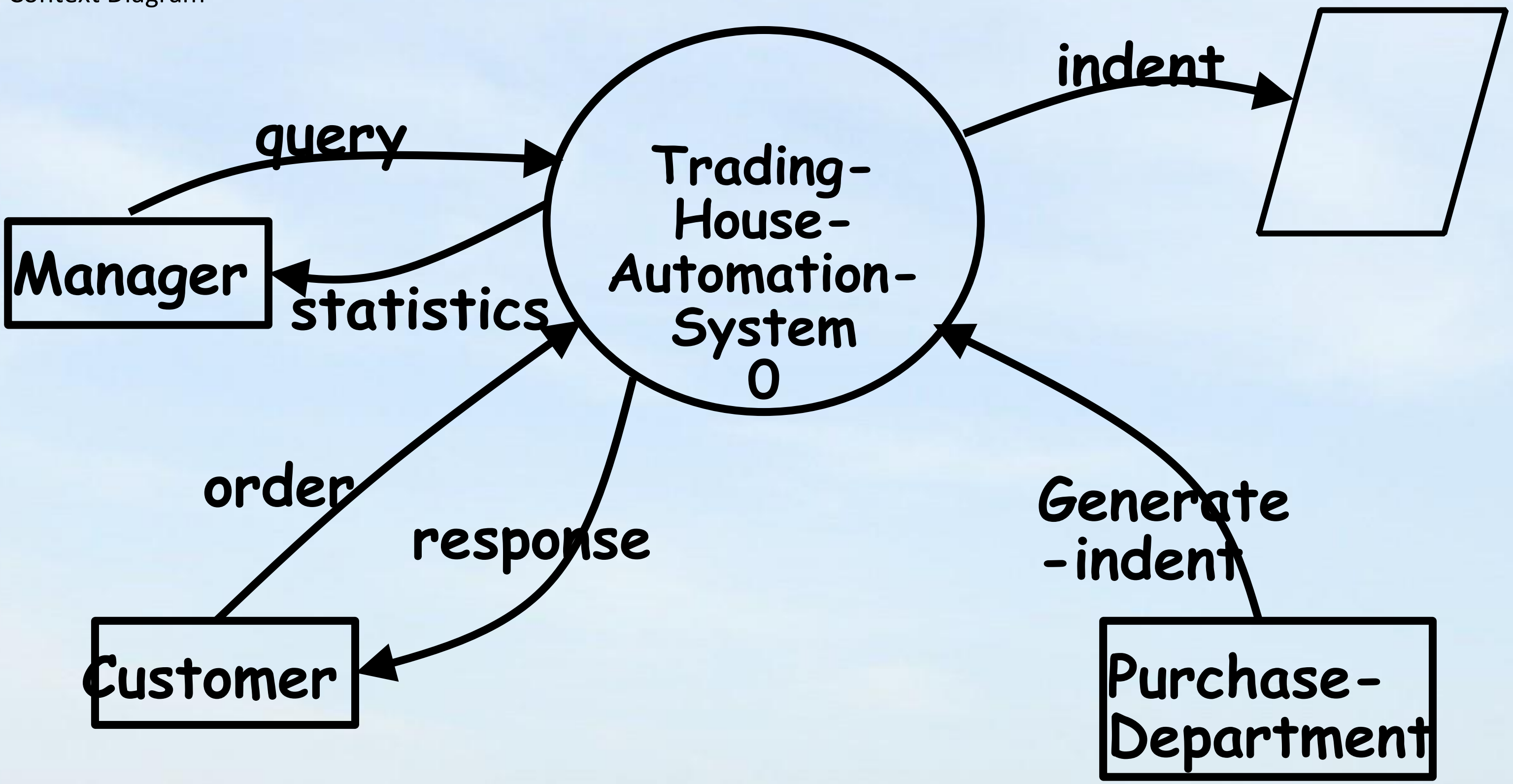
The items in a customer's order that the trading house deals with:

Are checked for availability in inventory.

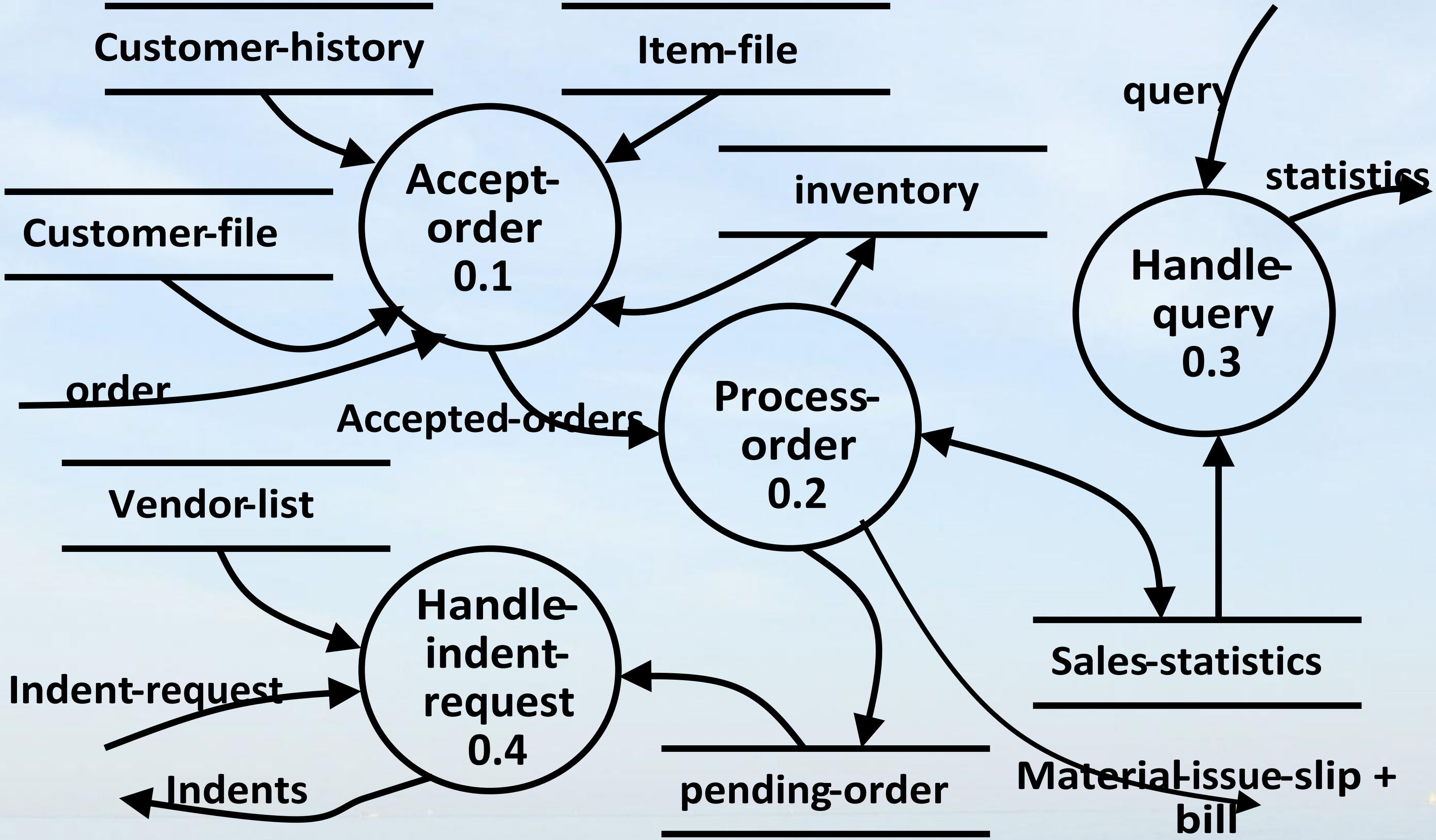
If the items are available in the inventory in desired quantities:
A bill with the forwarding address of the customer is printed.
A material issue slip is printed.

System (TAS)
The customer can produce the material issue slip at the store house:
•Take delivery of the items.
•Inventory data adjusted to reflect the sale to the customer.
System (TAS)
If an ordered item is not available in the inventory in sufficient quantity:
•To be able to fulfill pending orders store details in a "pending-order" file :
out-of-stock items along with quantity ordered.
customer identification number
System (TAS)
The purchase department:
•would periodically issue commands to generate indents.
When generate indents command is issued:
•The system should examine the "pending-order" file
•Determine the orders that are pending
•Total quantity required for each of the items.
System (TAS)
TAS should find out the addresses of the vendors who supply the required items:
•Examine the file containing vendor
details (their address, items they supply etc.)
•Print out indents to those vendors.
System (TAS)
TAS should also answers managerial queries:
•Statistics of different items sold over any given period of time
•Corresponding quantity sold and the price realized.

Context Diagram



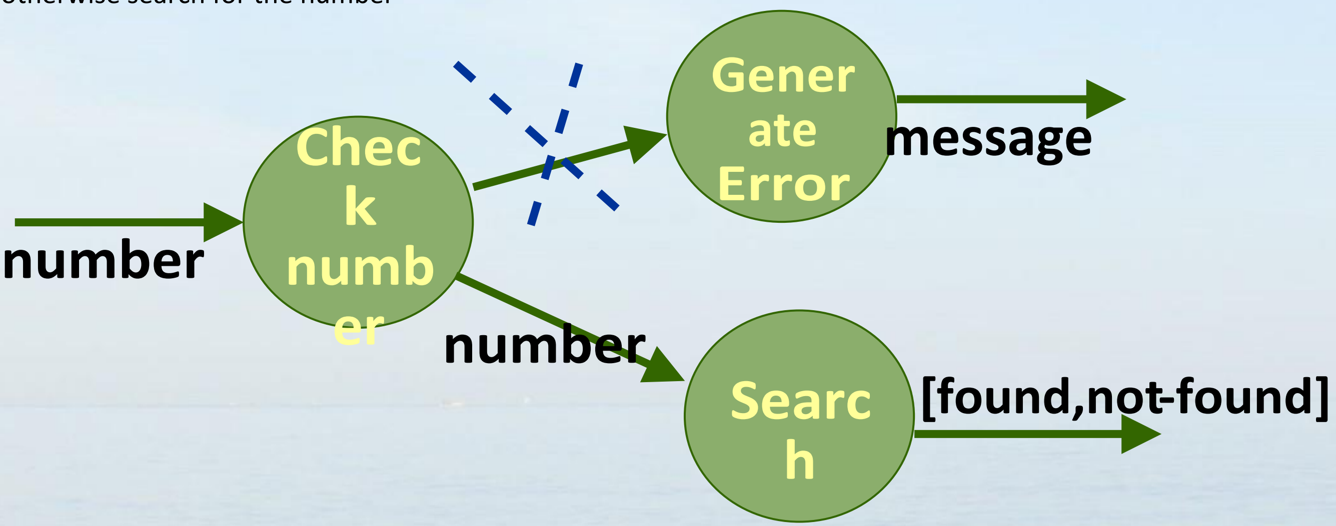
Level 1 DFD



Example: Data Dictionary
response: [bill + material-issue-slip, reject-message]
query: period /* query from manager regarding sales statistics*/
period: [date+date,month,year,day]
date: year + month + day
year: integer

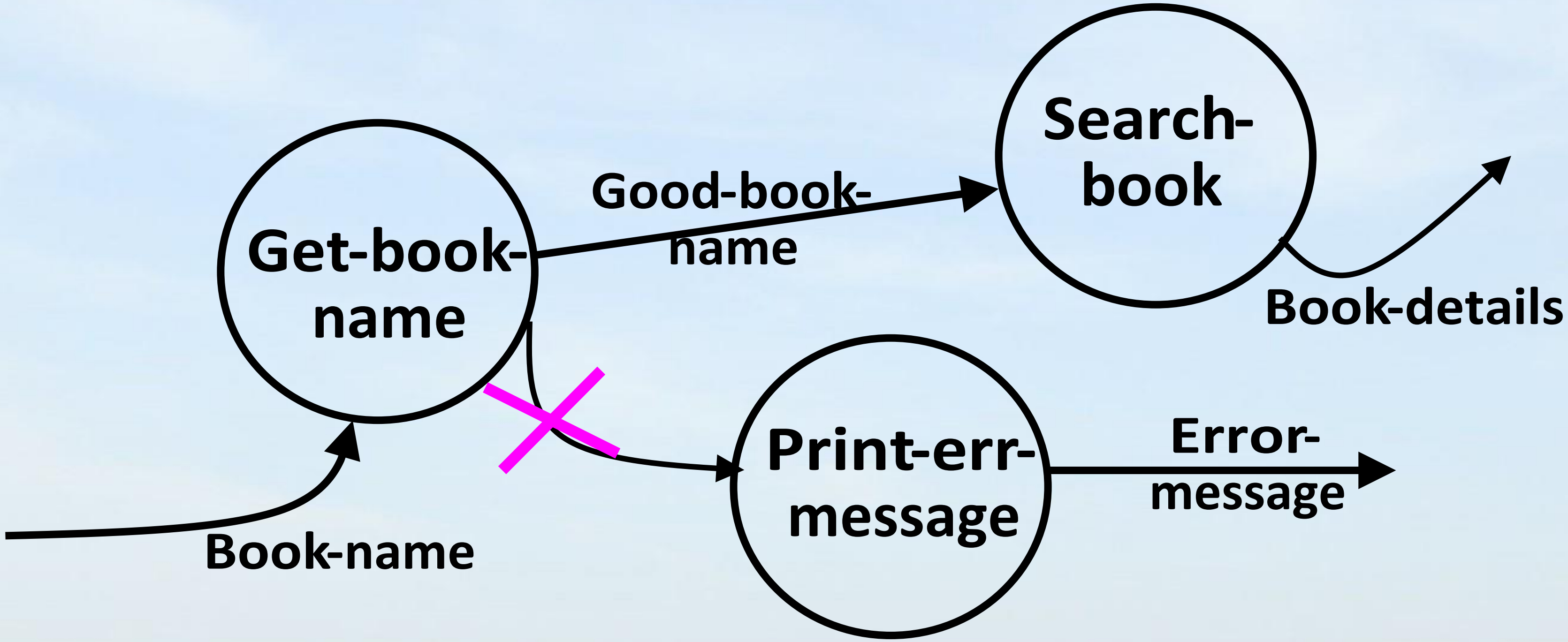
month: integer
day: integer
order: customer-id + {items + quantity}*
accepted-order: order /* ordered items available in inventory */
reject-message: order + message /* rejection message */
pending-orders: customer-id + {items+quantity}*
customer-address: name+house#+street#+city+pin
Example: Data Dictionary
item-name: string
house#: string
street#: string
city: string
pin: integer
customer-id: integer
bill: {item + quantity + price}* + total-amount + customer-address
material-issue-slip: message + item + quantity + customer-address
message: string
statistics: {item + quantity + price }*
sales-statistics: {statistics}*
quantity: integer
Observation
•From the examples,
•Observe that DFDs help create:
•Data model
•Function model
Observation
• As a DFD is refined into greater levels of detail:
•The analyst performs an implicit functional decomposition.
•At the same time, refinements of data takes place.
Guidelines For Constructing DFDs
• Context diagram should represent the system as a single bubble:
•Many beginners commit the mistake of drawing more than one bubble in the context diagram.
Guidelines For Constructing DFDs
All external entities should be represented in the context diagram:
External entities should not appear at any other level of DFD.

Only 3 to 7 bubbles per diagram should be allowed:
Each bubble should be decomposed to between 3 and 7 bubbles.
Guidelines For Constructing
DFDs
• A common mistake committed by many beginners:
•Attempting to represent control information in a DFD.
•e.g. trying to represent the order in which different functions are executed.
Guidelines For Constructing DFDs
A DFD does not represent control information:
When or in what order different functions (processes) are invoked
The conditions under which different functions are invoked are not represented.
For example, a function might invoke one function or another depending on some condition.
Many beginners try to represent this aspect by drawing an arrow between the corresponding bubbles.
Example-1
Check the input value:
If the input value is less than -1000 or greater than +1000 generate an error message
otherwise search for the number



Guidelines For Constructing DFDs
• If a bubble A invokes either bubble B or bubble C depending on some conditions:
•represent the data that flows from bubble A to bubble B and bubbles A to C
•not the conditions depending on which a process is invoked.

Example-2
A function accepts the book name to be searched from the user
If the entered book name is not a valid book name
Generates an error message,
If the book name is valid,
Searches the book name in database.

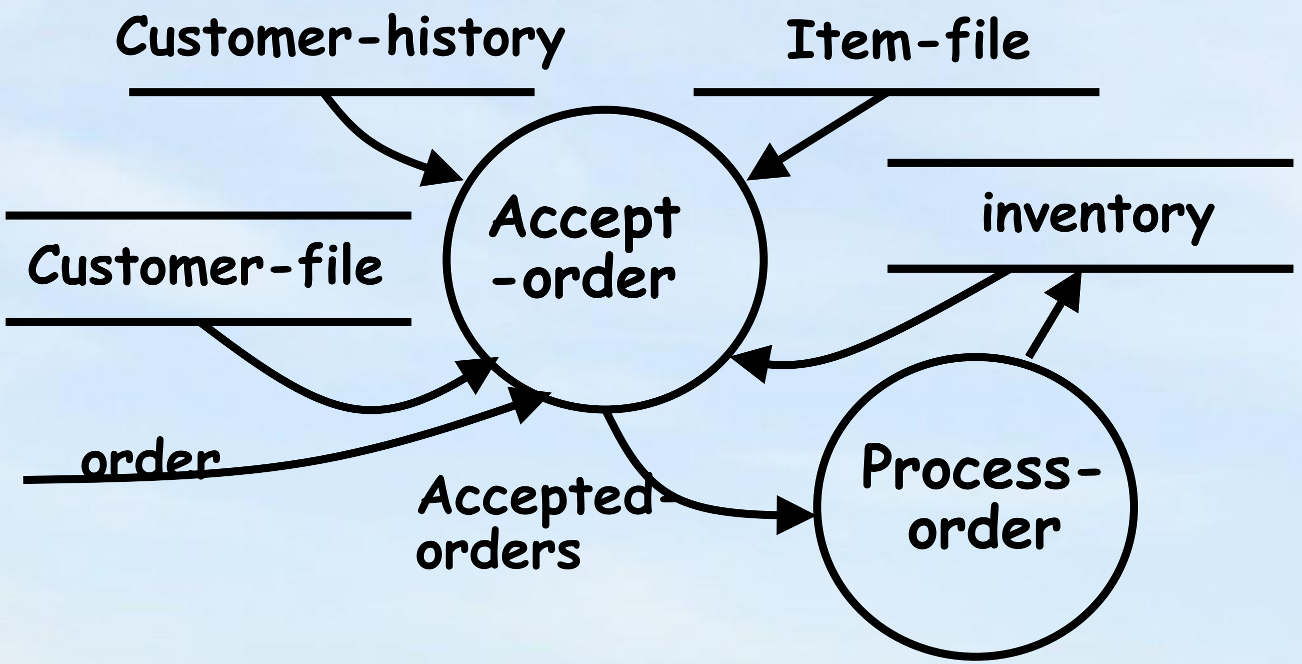


Guidelines For Constructing DFDs
All functions of the system must be captured in the DFD model:
- No function specified in the SRS document should be overlooked.

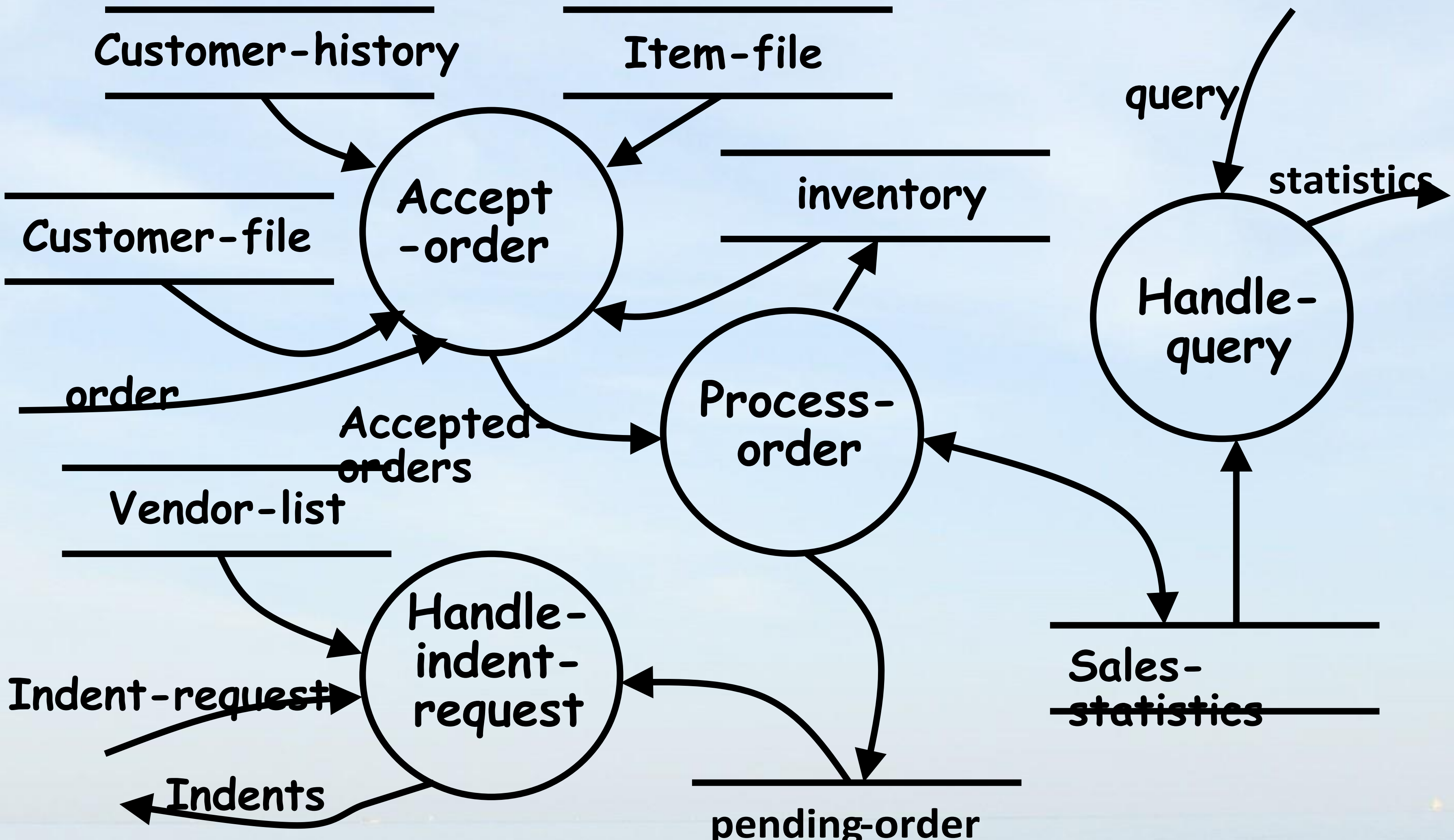
Only those functions specified in the SRS document should be represented:
- Do not assume extra functionality of the system not specified by the SRS document.

Commonly Made Errors
Unbalanced DFDs
Forgetting to mention the names of the data flows
Unrepresented functions or data
External entities appearing at higher level DFDs

Trying to represent control aspects
Context diagram having more than one bubble
A bubble decomposed into too many bubbles in the next level
Terminating decomposition too early
Nouns used in naming bubbles
Shortcomings of the DFD Model
DFD models suffer from several shortcomings:
DFDs leave ample scope to be imprecise.
•In a DFD model, we infer about the function performed by a bubble from its label.
•A label may not capture all the functionality of a bubble.
Shortcomings of the DFD Model
For example, a bubble named find-bookposition has only intuitive meaning:
•Does not specify several things:
What happens when some input information is missing or is incorrect.
Does not convey anything regarding what happens when book is not found
or what happens if there are books by different authors with the same book title.
Shortcomings of the DFD Model
Control information is not represented:
For instance, order in which inputs are consumed and outputs are produced is not specified.



Shortcomings of the DFD Model
A DFD does not specify synchronization aspects:
•For instance, the DFD in TAS example does not specify:
Whether process-order may wait until the acceptorder produces data
Whether accept-order and handle-order may proceed simultaneously with some buffering mechanism between them.
TAS: Level 1 DFD



Shortcomings of the DFD Model

The way decomposition is carried out to arrive at the successive levels of a DFD is subjective.

The ultimate level to which decomposition is carried out is subjective:

Depends on the choice and judgement of the analyst.

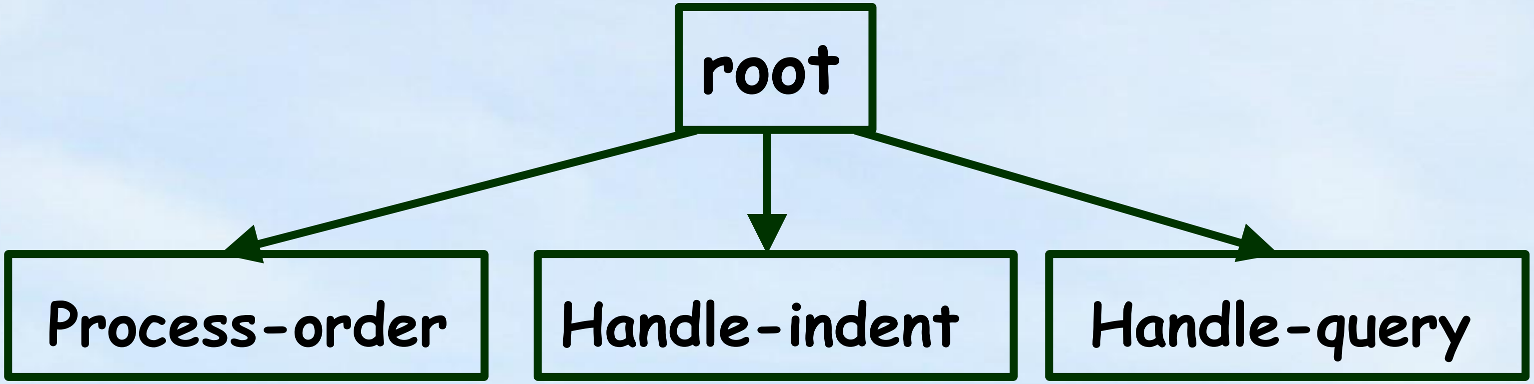
Even for the same problem,

Several alternative DFD representations are possible:

Many times it is not possible to say which DFD representation is superior or preferable.

Shortcomings of the DFD Model
DFD technique does not provide:
Any clear guidance as to how exactly one should go about decomposing a function:
One has to use subjective judgement to carry out decomposition.
Structured analysis techniques do not specify when to stop a decomposition process:
To what length decomposition needs to be carried out.
Extending DFD Technique to Real-Time Systems
For real-time systems (systems having time bounds on their actions),
•Essential to model control flow and events.
•Widely accepted technique: Ward and Mellor technique.
A type of process (bubbles) that handles only control flows is introduced.
These processes are represented using dashed circles.
Structured Design
The aim of structured design
Transform the results of structured analysis (i.e., a DFD representation) into a structure chart.
A structure chart represents the software architecture:
Various modules making up the system,
Module dependency (i.e. which module calls which other modules),
Parameters passed among different modules.
Structure Chart
Structure chart representation
Easily implementable using programming languages.
Main focus of a structure chart:
Define the module structure of a software,
Interaction among different modules,
Procedural aspects (e.g, how a particular functionality is achieved) are not represented.
Basic Building Blocks of Structure Chart
• Rectangular box:
•A rectangular box represents a module.
•Annotated with the name of the module it represents.

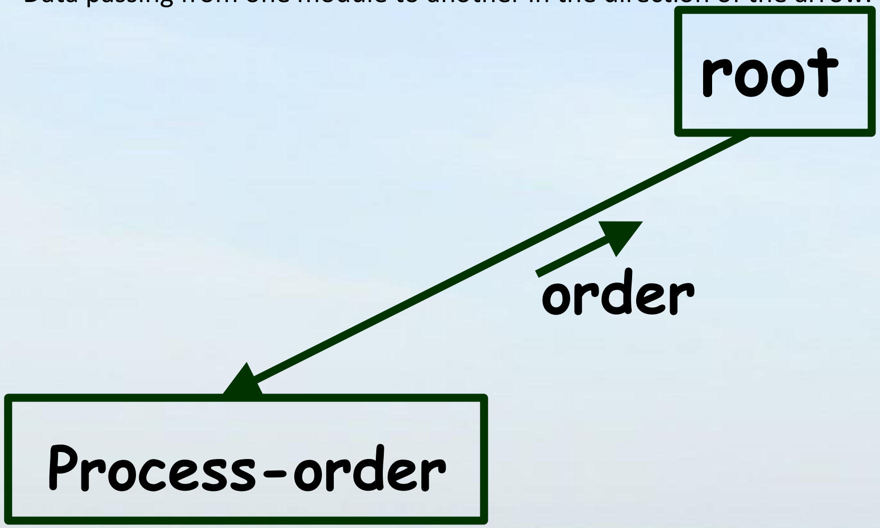
Process-order
Arrows
An arrow between two modules implies:
During execution control is passed from one module to the other in the direction of the arrow.



Data Flow Arrows

• Data flow arrows represent:

•Data passing from one module to another in the direction of the arrow.



Library Modules

Library modules represent frequently called modules:

A rectangle with double side edges.

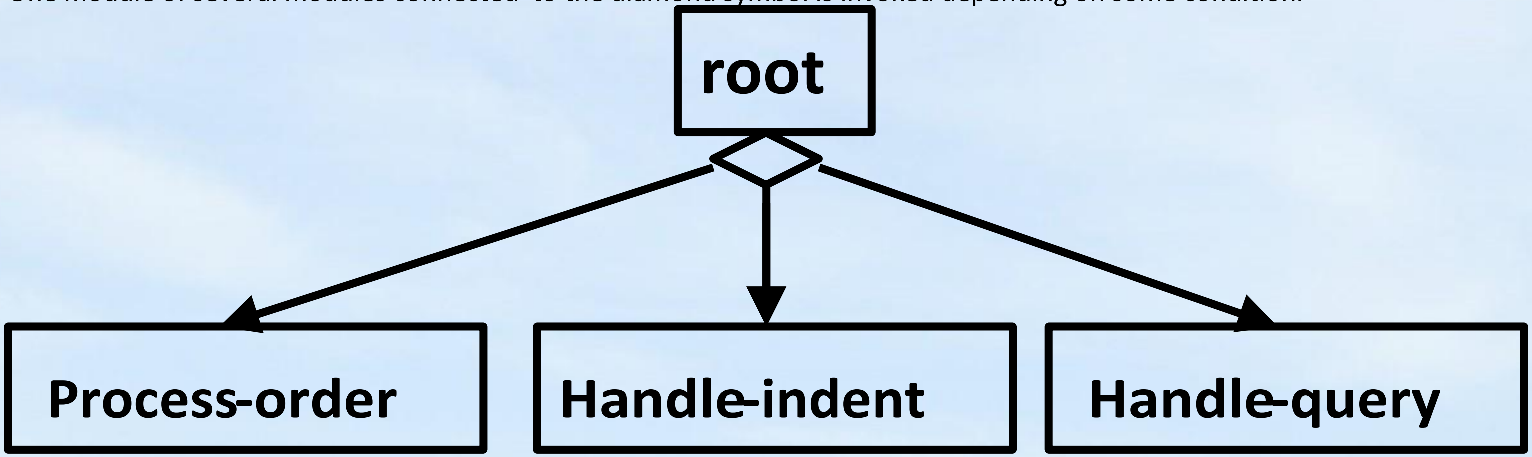
•Simplifies drawing when a module is called by several modules.

Quick-sort

Selection

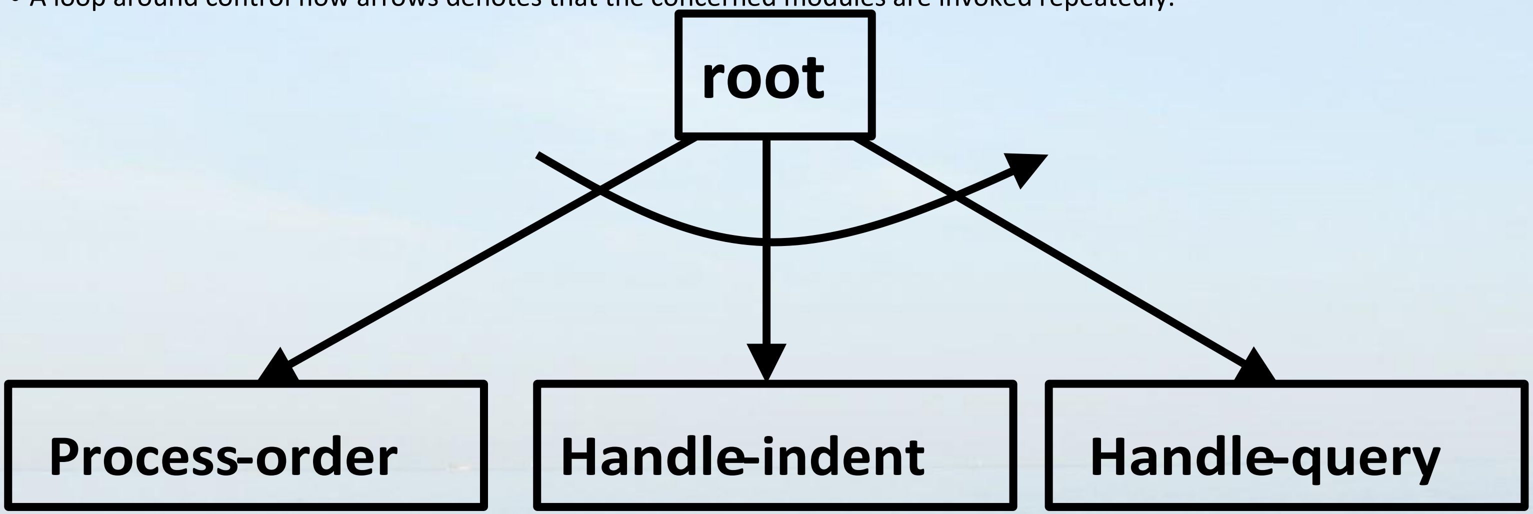
The diamond symbol represents:

One module of several modules connected to the diamond symbol is invoked depending on some condition.



Repetition

• A loop around control flow arrows denotes that the concerned modules are invoked repeatedly.



Structure Chart

There is only one module at the top:

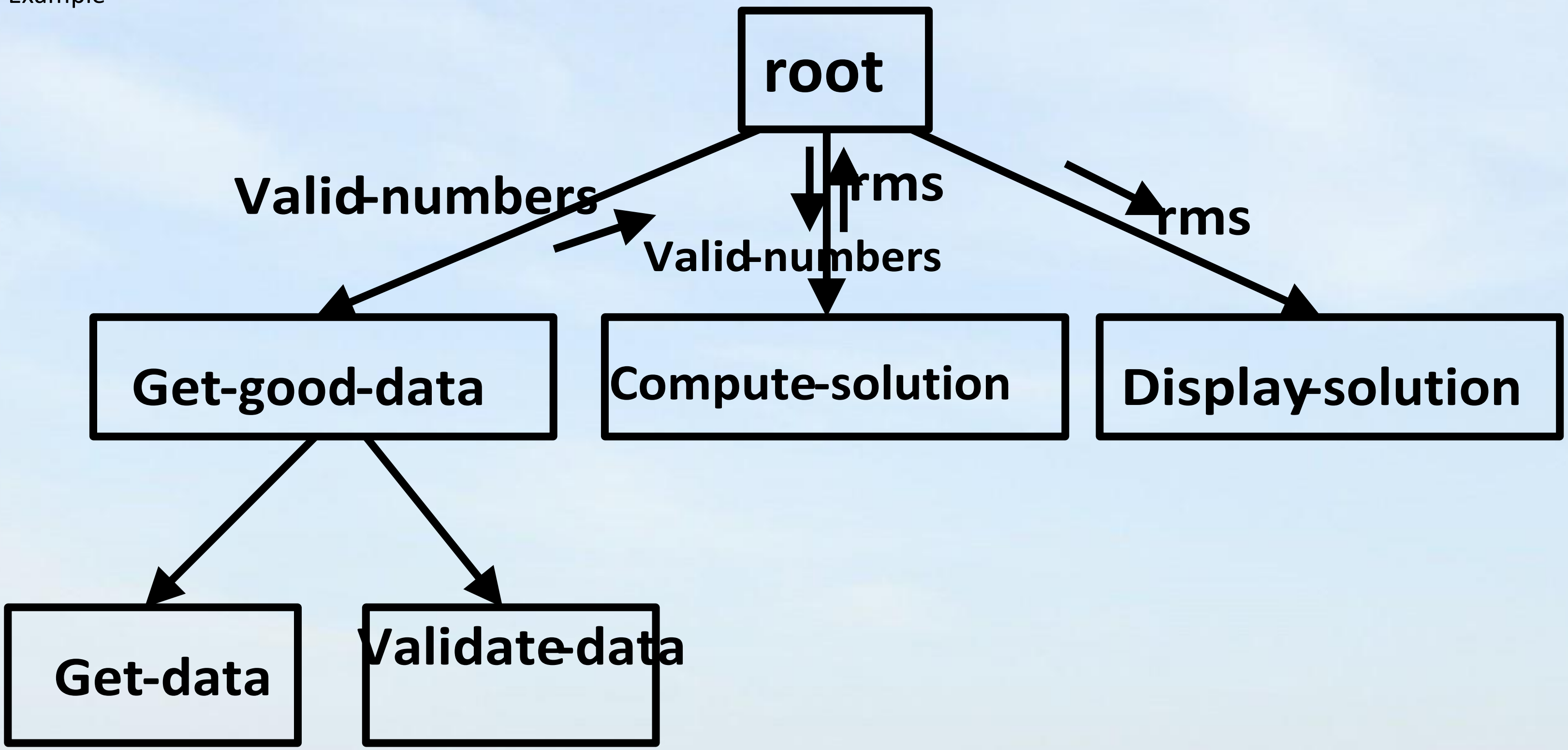
the root module.

There is at most one control relationship between any two modules:

if module A invokes module B,

Module B cannot invoke module A.

The main reason behind this restriction:
consider modules in a structure chart to be arranged in layers or levels.
Example



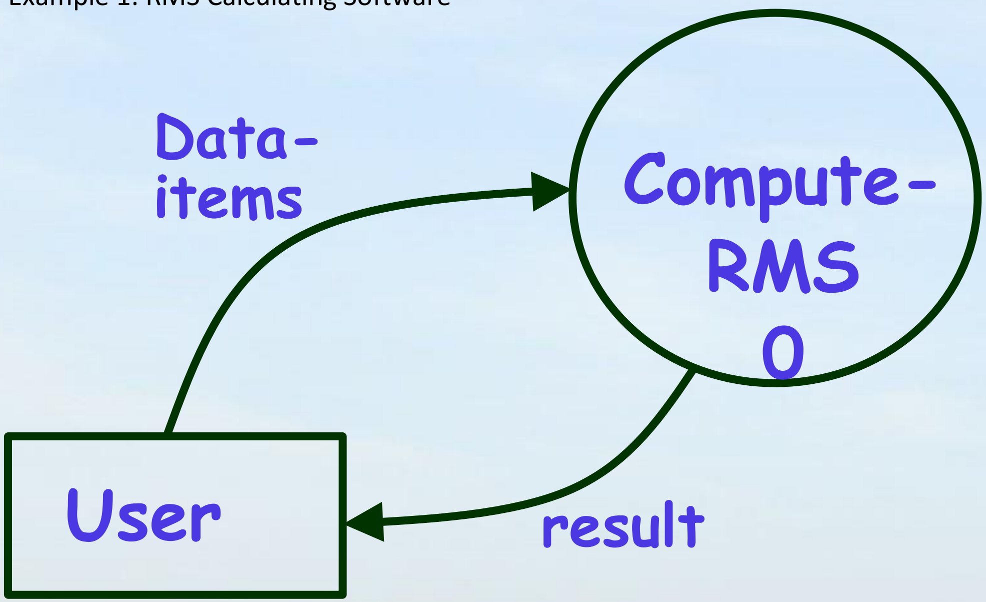
Shortcomings of Structure Chart
By looking at a structure chart:
•we can not say whether a module calls another module just once or many times.
Also, by looking at a structure chart:
•we can not tell the order in which the different modules are invoked.
Flow Chart versus Structure Chart
A structure chart differs from a flow chart in three principal ways:
•It is difficult to identify modules of a software from its flow chart representation.
•Data interchange among the modules is not represented in a flow chart.
•Sequential ordering of tasks inherent in a flow chart is suppressed in a structure chart.
Transformation of a DFD Model into Structure Chart

Two strategies exist to guide transformation of a DFD into a structure chart:
•Transform Analysis
•Transaction Analysis
Transform Analysis
• The first step in transform analysis:
•Divide the DFD into 3 parts:
•input,
•logical processing,
•output.
Transform Analysis
Input portion in the DFD:
processes which convert input data from physical to logical form.
e.g. read characters from the terminal and store in internal tables or lists.
Each input portion:
called an afferent branch.
Possible to have more than one afferent branch in a DFD.

Transform Analysis

Output portion of a DFD:
•transforms output data from logical form to physical form.
e.g., from list or array into output characters.
•Each output portion:
called an efferent branch.
The remaining portions of a DFD
•called central transform
Derive structure chart by drawing one functional component for:
•the central transform, •each afferent branch,
•each efferent branch.
Identifying the highest level input and output transforms:
requires experience and skill.
Some guidelines:
Trace the inputs until a bubble is found whose output cannot be deduced from the inputs alone.
Processes which validate input are not central transforms.
Processes which sort input or filter data from it are.
First level of structure chart:
•Draw a box for each input and output units
•A box for the central transform.
Next, refine the structure chart:
•Add subfunctions required by each high-level module.
•Many levels of modules may required to be added.

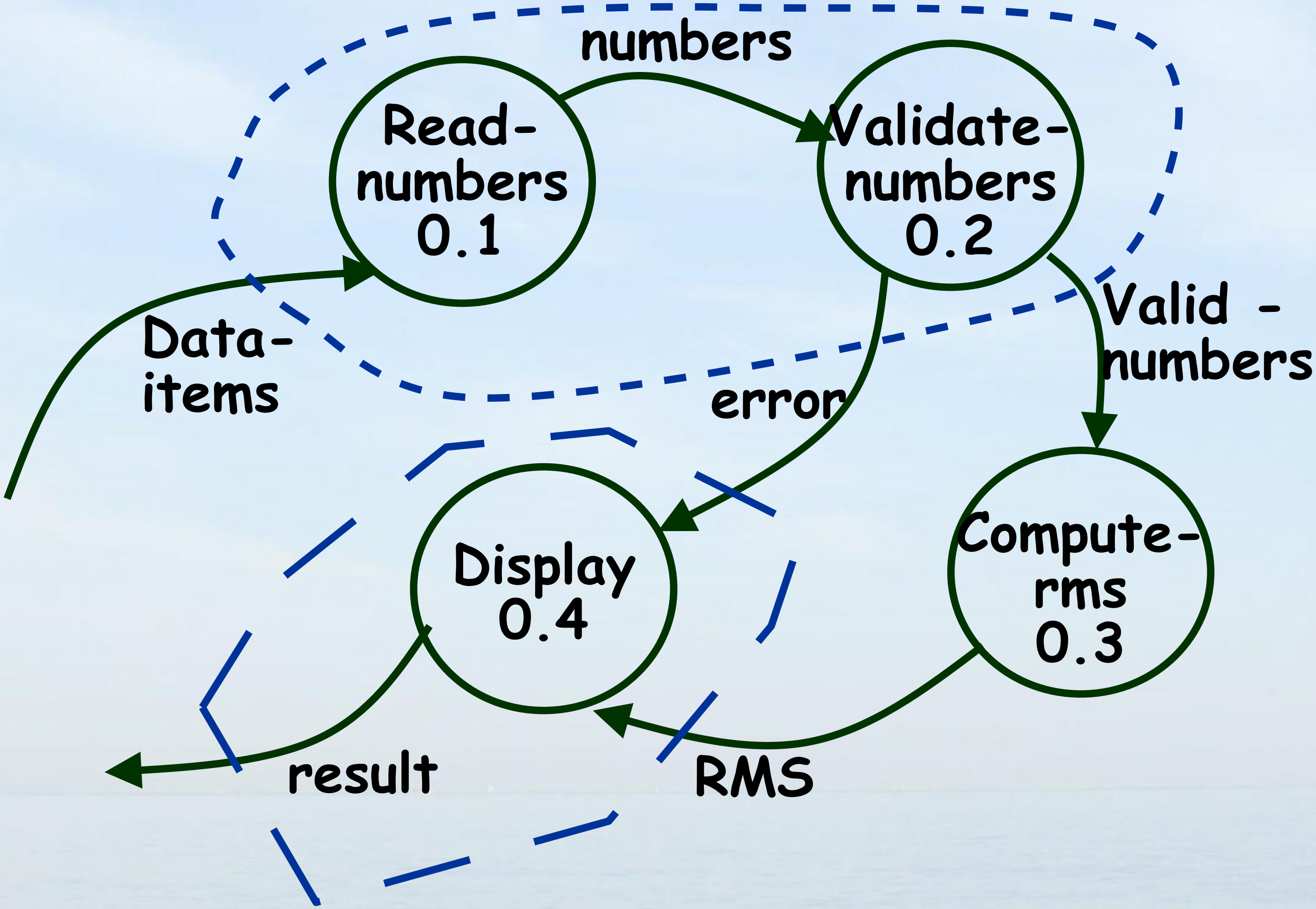
Factoring
The process of breaking functional components into subcomponents.
Factoring includes adding:
•Read and write modules,
•Error-handling modules,
•Initialization and termination modules, etc.
Finally check:
•Whether all bubbles have been mapped to modules.
Example 1: RMS Calculating Software



Context Diagram

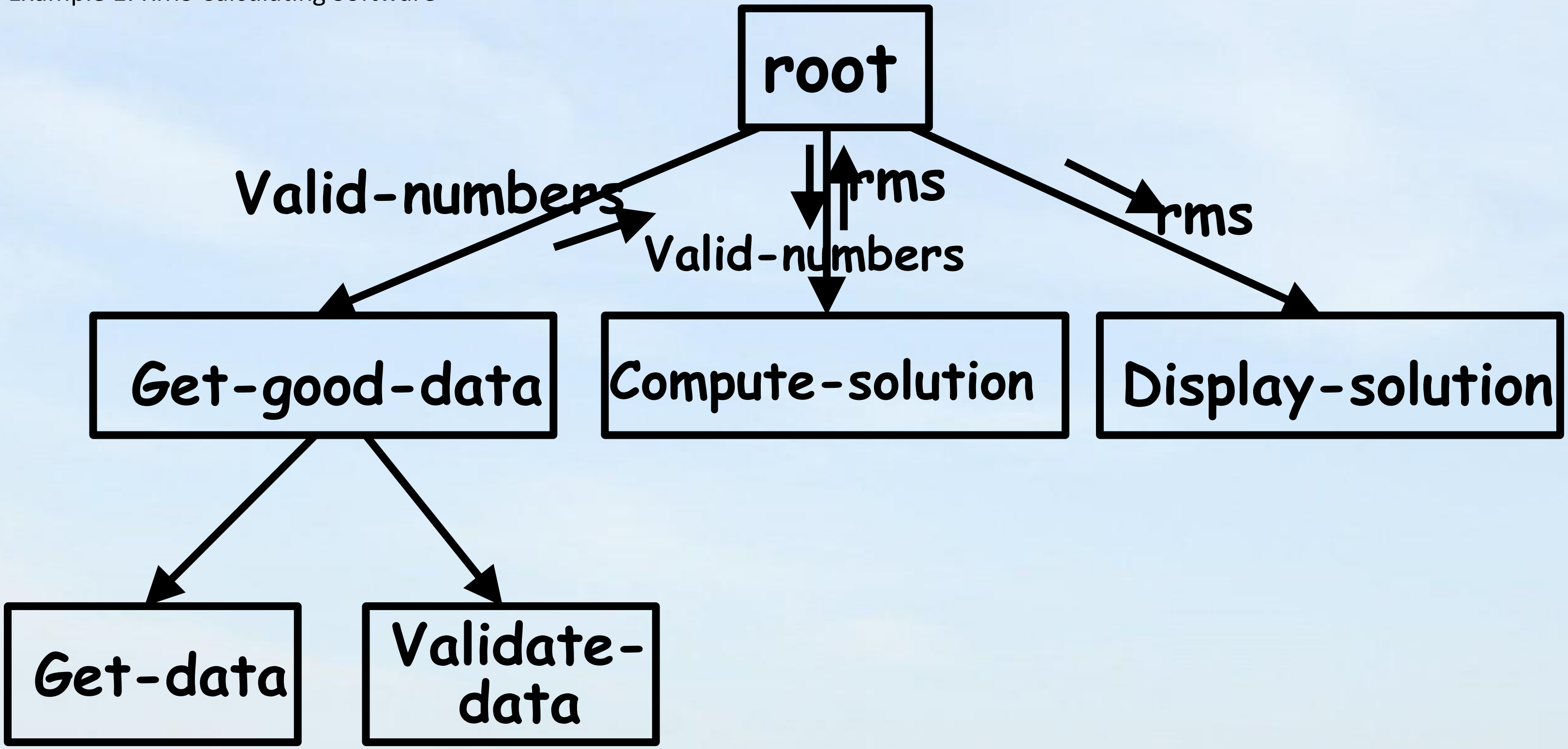
Example 1: RMS Calculating Software
From a cursory analysis of the problem description,
•easy to see that the system needs to perform:
accept the input numbers from the user,

validate the numbers,
calculate the root mean square of the input numbers,
display the result.
Example 1: RMS Calculating Software

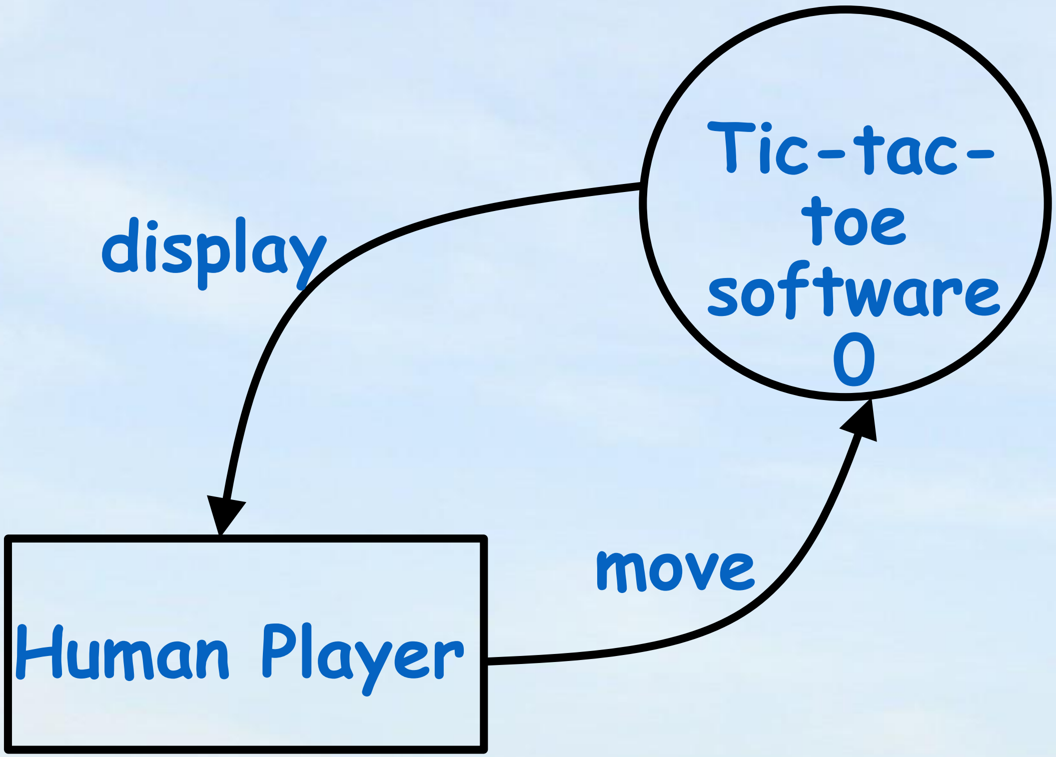


Example 1: RMS Calculating Software
• By observing the level 1 DFD:
•Identify read-number and validatenumber bubbles as the afferent branch

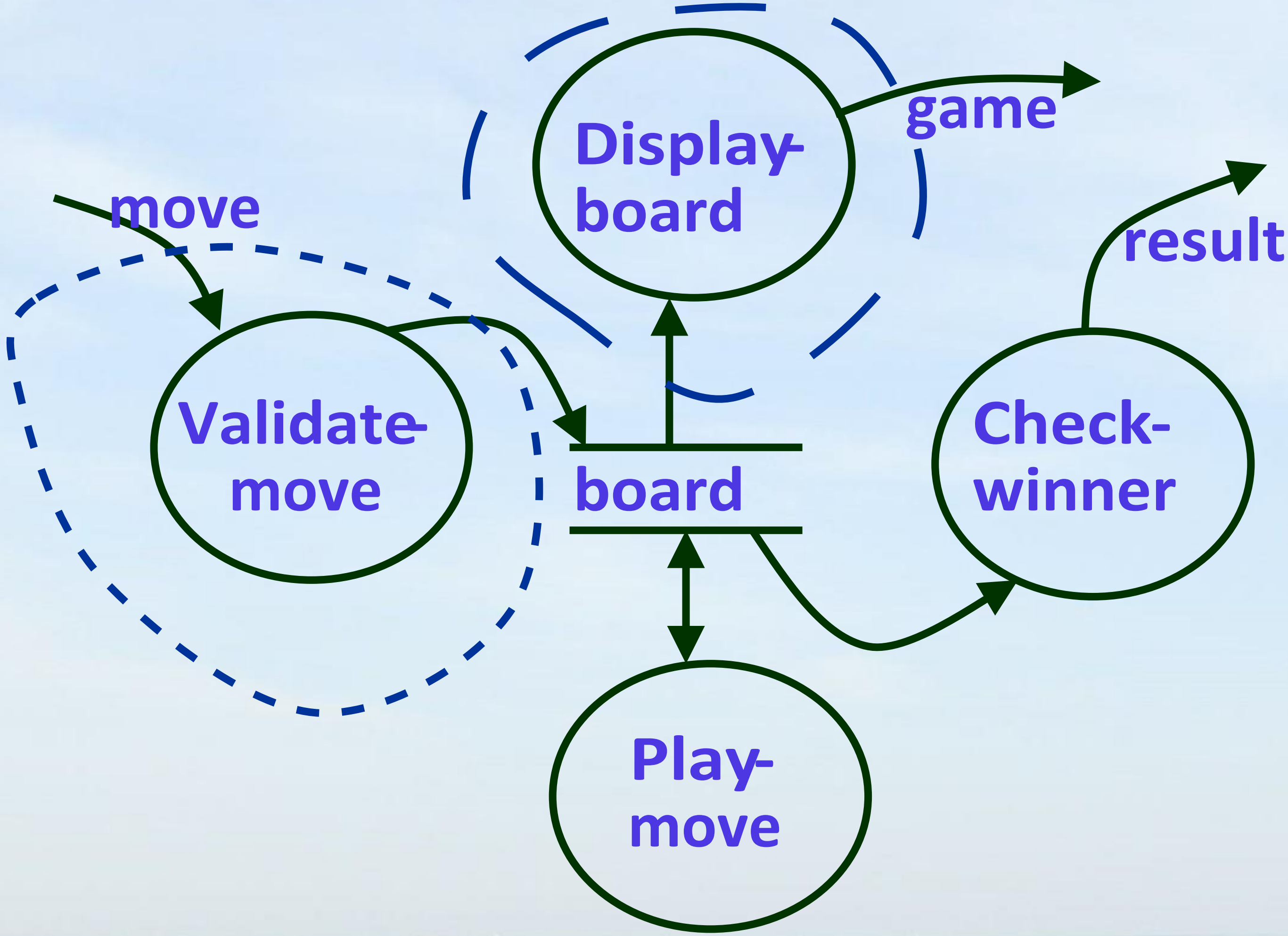
•Display as the efferent branch.
Example 1: RMS Calculating Software



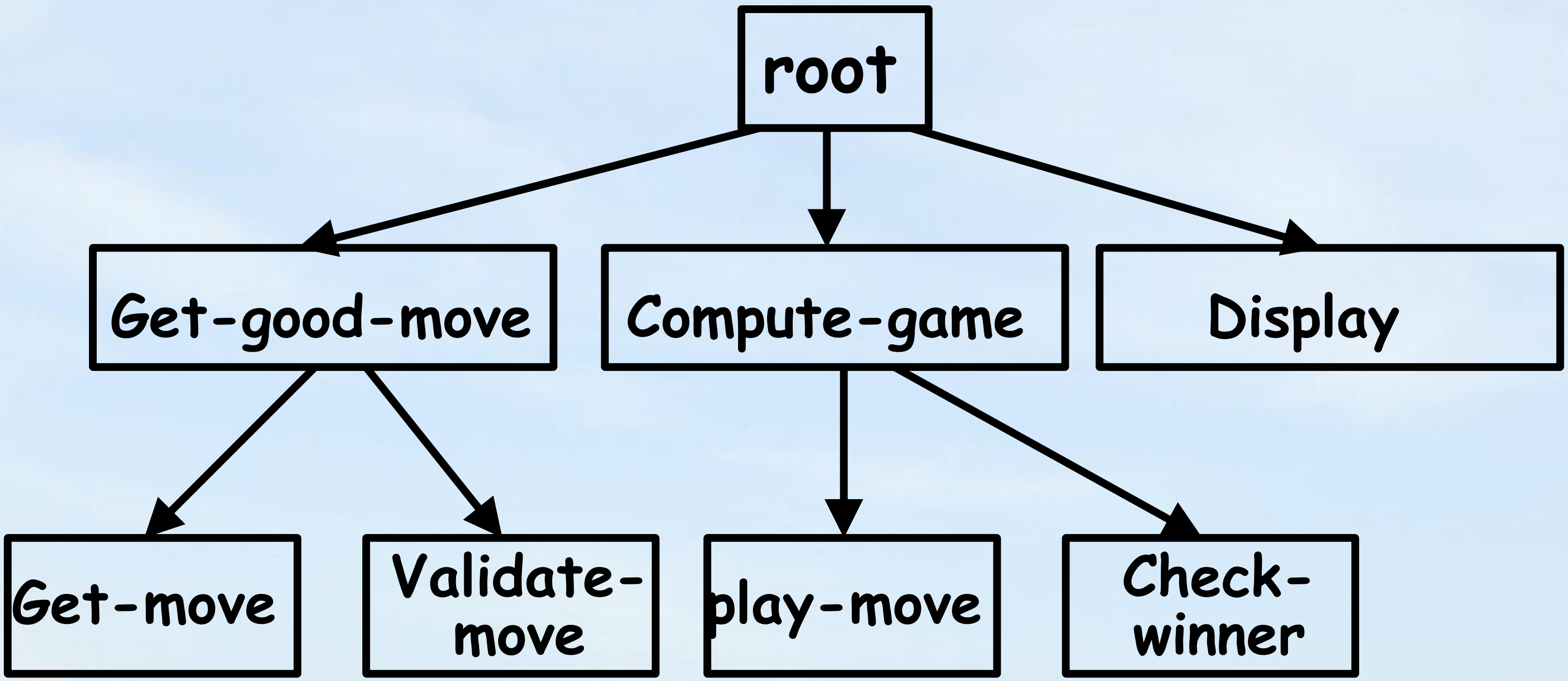
Example 2: Tic-Tac-Toe Computer Game
As soon as either of the human player or the computer wins,
A message congratulating the winner should be displayed.
If neither player manages to get three consecutive marks along a straight line,
And all the squares on the board are filled up,
Then the game is drawn.
The computer always tries to win a game.
Context Diagram for Example 2



Level 1 DFD



Structure Chart



Transaction Analysis

Useful for designing transaction processing programs.

•Transform-centered systems:

Characterized by similar processing steps for every data item processed by input, process, and output bubbles.

•Transaction-driven systems,

One of several possible paths through the DFD is traversed depending upon the input data value.

Transaction Analysis

Transaction:

•Any input data value that triggers an action:

•For example, selected menu options might trigger different functions.

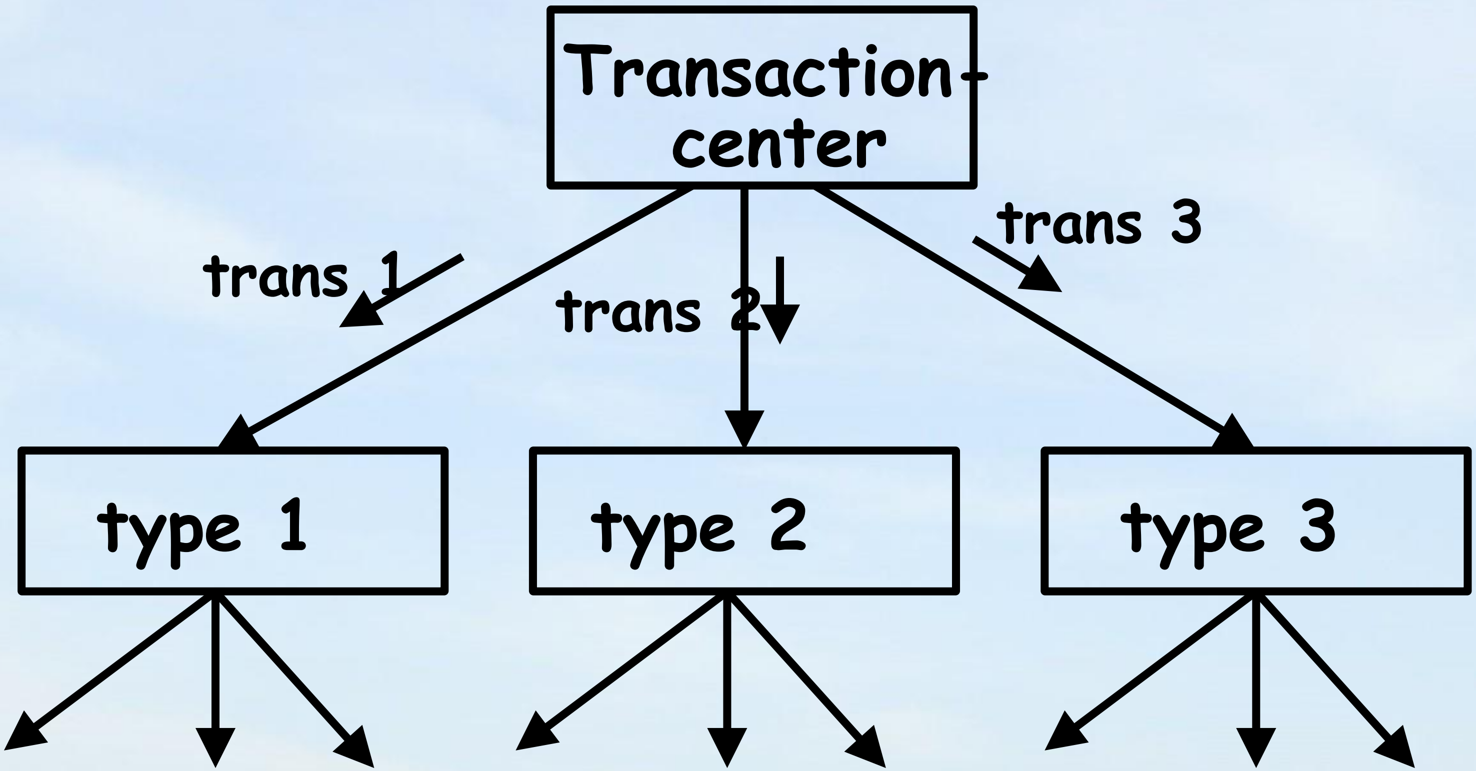
•Represented by a tag identifying its type.

Transaction analysis uses this tag to divide the system into:

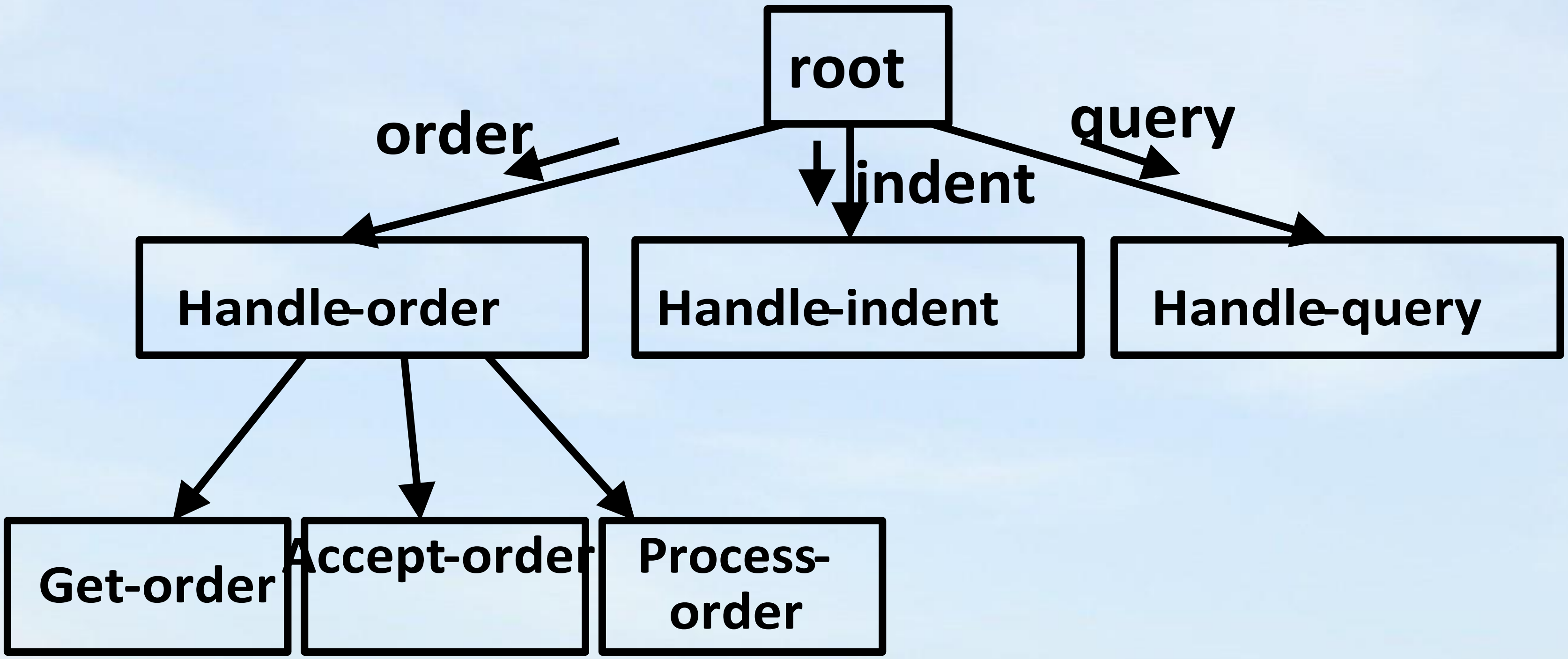
•Several transaction modules

•One transaction-center module.

Transaction analysis



Structure Chart



Summary

We first discussed structured analysis of a larger problem.
We defined some general guidelines
for constructing a satisfactory DFD model.
The DFD model though simple and useful
does have several short comings.
We then started discussing structured design.

Summary

Aim of structured design:

- Transform a DFD representation into a structure chart.

Structure chart represents:

- Module structure
- Interaction among different modules,
- Procedural aspects are not represented.

Summary

• Structured design provides two strategies to transform a DFD into a structure chart:
•Transform Analysis
•Transaction Analysis
Summary
We Discussed three examples of structured design.
It takes a lot of practice to become a good software designer:
•Please try to solve all the problems listed in your assignment sheet,
Not only the ones you are expected to submit.